

IN THE APPLICATION

OF

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FOR AN

MAGNETICALLY DRIVEN WHEEL FOR USE IN
A RADIAL/ROTARY PROPULSION SYSTEM
HAVING AN ENERGY RECOVERY FEATURE

**MAGNETICALLY DRIVEN WHEEL FOR USE IN A RADIAL/ROTARY
PROPULSION SYSTEM HAVING AN ENERGY RECOVERY FEATURE**

RELATED APPLICATIONS:

5 This application is a Continuation-in-Part of
United States Patent Application Serial No. 09/256,847,
filed March 10, 1999, which was in turn a Continuation
of United States Provisional Patent Application, Serial
No. 60/103,898, filed October 13, 1998.

BACKGROUND OF THE INVENTION

10 **1. FIELD OF THE INVENTION**

The present invention relates to a magnetically
driven flywheel or wheel and, more particularly, the
invention features a flywheel equipped with rings of
permanent magnets adapted to interact with external,
15 DC, capacitive discharge powered electromagnets to
rotate the flywheel. Energy recovery is by the inertia
of the flywheel propelling alternators used to generate
electrical power to recharge a battery.

2. DESCRIPTION OF THE PRIOR ART

A magnetic wheel drive is described in United States Patent No. 4,179,633 for MAGNETIC WHEEL DRIVE; issued to Donald A. Kelly on December 18, 1979. Kelly teaches a wheel having a series of permanent magnets radially disposed along its circumference. These permanent magnets are arranged to interact with a series of pairs of permanent magnets placed on oscillating, toggle bars powered by an external motive force. The "flipping" of the toggle bars alternately place the north and south poles of the magnet couples in close proximity to the permanent magnets on the wheel. By synchronizing the toggling of the fixed magnets, alternate north and south poles attract oncoming, rotating wheel magnets. By controlling the speed of the toggling, the rotational speed of the wheel may be controlled.

In contradistinction, the radial/rotary propulsion system of the instant invention requires no external, toggling of permanent magnet couples. Unlike KELLY, the inventive radial rotary propulsion system uses DC energized electromagnets in a repulsion only modality. The inventive apparatus uses permanent magnets on a flywheel in rings of varying diameters which, in turn,

interact with selectively with the DC, capacitive
discharge powered electromagnets on one or both sides
of the rotating flywheel. The use of concentric rings
of permanent magnets helps simplify the speed control
5 of the device and allows more efficient operation over
a range of torque requirements. In addition, when the
flywheel is not being powered, the inertia of the
flywheel allows generation of electrical power which
may be used to recharge the battery normally used to
10 power the electromagnets. This helps to re-energize
the system so that it can be used for vehicle
propulsion or in other similar applications, while
decreasing the total drain from the battery system.

United States Patent No. 5,600,191 for DRIVING
15 ASSEMBLY FOR MOTOR WHEELS; issued February 4, 1997 to
Chen-Chi Yang, teaches another apparatus for
magnetically imparting rotary motion to a wheel. Yang
also uses permanent magnets radially arranged at the
circumference of a stator (wheel) to interact with
20 external electromagnet coils. A clutch mechanism is
provided to selectively couple the rotary motion to an
axle. The present invention, on the other hand,
utilizes permanent magnets embedded in, or mounted on
one or both faces of a flywheel and arranged in
25 concentric rings of varying diameters which, in turn,

interact with selectively energizable electromagnets,
also arranged in concentric rings so as to interact
with corresponding rings of permanent magnets on the
flywheel. In the inventive radial/rotary propulsion
5 system, magnetic interaction between the permanent and
the electromagnets is always repulsive, unlike YANG who
relies upon an arrangement of north-south poles to
provide a attraction/repulsion mode of operation.
Regenerative elements allow recapture of inertial
10 energy of the flywheel for the purpose of recharging a
battery.

In United States Patent No. 5,719,458 for POWER
GENERATOR WITH IMPROVED ROTOR; issued February 17, 1998
to Teruo Kawal, another apparatus for imparting rotary
15 motion to a wheel is described. KAWAL utilizes an AC
current, preferably three-phase AC, to energize
electromagnets to create an alternating magnetic field
which interacts with semicircular pole pieces on the
perimeter of the wheel. Unlike Applicant's nonmagnetic
20 wheel, the KAWAL wheel is itself, a relatively complex
magnetic structure. The KAWAL system relies upon an
alternating north-south pole arrangement to implement an
attraction/repulsion mode of operation. The present
invention, on the other hand, utilizes a DC, capacitive
25 discharge system to selectively energize the

electromagnets which interact with concentric circles of permanent magnets, all having the same polarity within any given magnet ring, the inventive system operating in a repulsion only mode. Also, unlike the KAWAL pole pieces, the permanent magnets of the instant invention need have no special physical shape (i.e., they need not be semicircular, etc.).

While in each one of these prior art inventions, apparatus for imparting rotary motion to a wheel through the interaction of permanent magnets with a magnetic field from electromagnets is described, none of the above inventions and patents, taken either singly or in combination, is seen to describe the instant invention as claimed

SUMMARY OF THE INVENTION

The radial/rotary propulsion system of the present invention features a flywheel having concentric rings of permanent magnets attached to or embedded in one or both faces. These permanent magnets are arranged on the flywheel such that all magnets in a ring on a given face have the same polarity (i.e., they are all either north or south poles). The magnets interact with DC powered electromagnets which, when selectively energized,

typically using capacitive discharge energization, to provide magnetic fields which impart rotary motion to the flywheel. By arranging the permanent magnets in concentric rings and using repulsion only operation, better control of both speed and output torque may be obtained. The use of narrow pulse width DC pulses, such as may be obtained from a capacitive discharge type power supply, also helps to control the inventive radial/rotary propulsion system and facilitates operation at high speed, for example at speed in the vicinity of 6000 rpm. By using narrow, high-energy pulses, necessary energy for high-torque output may be obtained with still operating at high rotational rates. In addition, in a regenerative mode, inertia of the flywheel is reconverted to electrical energy by either additional permanent magnet/coil combinations, or through the switching of the electromagnet coils normally used for rotating the flywheel, or by alternators positioned on the flywheel housing and tensioned against the flywheel. The energy recapture feature is particularly useful when the flywheel is utilized in a self-propelled vehicle powered by self-contained, rechargeable batteries.

Accordingly, it is a principal object of the invention provide a magnetically powered, rotary propulsion system.

5 It is an additional object of the invention to provide a magnetically powered, rotary propulsion system utilizing a flywheel made from a dense, magnetically nonconductive material.

10 It is another object of the invention to provide a magnetically powered, rotary propulsion system utilizing permanent magnets mounted on or embedded in the flat faces of the flywheel.

15 It is a further object of the invention to provide a magnetically powered, rotary propulsion system wherein the permanent magnets on the flat faces of the flywheel are arranged in concentric rings.

It is a still further object of the invention to provide a magnetically powered, rotary propulsion system wherein the permanent magnets in any ring all have the same polarity.

20 Still another object of the invention is to provide a magnetically powered, rotary propulsion system wherein

the concentric rings of magnets interact with
selectively energized, DC powered electromagnets.

5 It is an additional object of the invention to
provide a magnetically powered, rotary propulsion system
wherein the selectively energized, DC powered
electromagnets are energized using a capacitive
discharge energization system.

10 An additional object of the invention is to provide
a magnetically powered, rotary propulsion system having
the ability to recapture inertial flywheel energy as
electrical power.

15 It is again an object of the invention to provide a
magnetically powered, rotary propulsion system suitable
for use in powering a self-propelled vehicle.

It is another object of the invention to provide a
magnetically powered, rotary propulsion system wherein
the magnetically driven flywheel is directly attached or
forms a part of the wheel of a self-propelled vehicle.

20 Yet another object of the invention is to provide a
magnetically powered, rotary propulsion system suitable
for use in powering a self-propelled vehicle either by

direct wheel drive or a motor incorporating the magnetically powered, rotary propulsion flywheel.

It is an object of the invention to provide improved elements and arrangements thereof in an apparatus for the purposes described which is
5 inexpensive, dependable and fully effective in accomplishing its intended purposes.

These and other objects of the present invention will become readily apparent upon further review of the
10 following specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Various other objects, features, and attendant advantages of the present invention will become more fully appreciated as the same becomes better understood
15 when considered in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the several views, and wherein:

FIGURE 1 is a plan view of the permanent magnet
20 equipped flywheel of the invention;

FIGURE 2 is a side schematic of the radial/rotary propulsion system utilizing the flywheel shown in FIGURE 1;

FIGURE 3 is a side schematic of the radial/rotary propulsion system showing an energy recapture mechanism including alternators for electrical regeneration;

FIGURE 4 is a side view of the permanent magnet equipped flywheel of the invention showing partially embedded magnets;

FIGURE 5 is a side view of the permanent magnet equipped flywheel of the invention showing fully embedded magnets;

FIGURE 6 is a system schematic block diagram of a control system for an electrically powered vehicle using the radial/rotary propulsion system of the invention;

FIGURE 7 is a schematic view of an electrically powered vehicle utilizing the radial/rotary propulsion system of the invention for the drive wheels; and

FIGURE 8 is a schematic, plan view of an alternate, simplified embodiment of the magnet equipped flywheel shown in FIGURE 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIGURES 1 and 2, there are shown a plan view and a side view, respectively, of a first embodiment of the radial/rotary propulsion system of the present invention, generally at reference number 10. A flywheel 12 is shown mounted on axle 14 through bearing assembly 16. Bearing assembly 16 is typically a one-way bearing to allow rotation of flywheel 12 in a single, predetermined direction and/or to allow coupling of the rotational motion of flywheel 12 to axle 14. Making bearing 16 a one-way bearing simplifies the electrical control (not shown) and guarantees rotation of flywheel 12 in a known direction at start-up. If a two-way bearing is used, an additional mechanism (not shown) for coupling the rotational motion of flywheel 12 to axle 14 must be provided. Such mechanisms are well known to those skilled in the art. Flywheel 12 is composed of a dense but magnetically nonconductive material. Brass, bronze, or certain nonmagnetic stainless steel alloys have been found suitable. A composite structure having a dense material such as lead bonded between structurally rigid plates could also be employed. The greater the mass of flywheel 12, the smoother the performance of the inventive radial/rotary propulsion system. Bearing assembly 16 allows flywheel 12 to

rotate freely about axle 14 in a single, predetermined direction, assuming that bearing assembly 14 is a one way bearing. Permanent magnets 18, 20 are affixed to a side surface (i.e., face) of flywheel 12. Magnets 18, 20 may be affixed to flywheel 12 using a structural adhesive or any mechanical fastening means suitable to withstand the centrifugal forces to which the magnets 18, 20 are subjected. Such fastening means are well known to those skilled in the art. Magnets 18 are arranged in a substantially circular pattern at a first radius from the center of axle 14 forming a first magnet group 22. Likewise, magnets 20 are arranged in a substantially circular pattern at a second, smaller radius from the center of axle 14. Any number of magnets may be used in first magnet group 22 or second magnet group 24, although an even number is preferable, the magnets 18, 20 being arranged so that all magnets in magnet groups 22, 24 present the same polarity (i.e., the poles presented for interaction with external electromagnets are all are north poles or all are south poles). Permanent magnets 18, 20 must be spaced far enough apart around the face of flywheel 12 so as to provide a break in the magnetic fields generated by adjacent magnets. If sufficient space is not provided, either the inventive system will not operate at all, or will operate inefficiently. Permanent magnets

18, 20 may be provided on one or both faces of flywheel
12.

A series of electromagnets 26, 28 are positioned
with their poles as close as possible to the first
5 magnet group 22 and second magnet group 24,
respectfully. Electrical leads 30, 32 are connected to
a controller/sequencer 40 (FIGURE 6) which selectively
applies power, generally from a capacitive discharge
power supply circuit (not shown), typically forming a
10 part of controller/sequencer 40. Power for
electromagnets 26, 28 is provided by battery 38 (FIGURE
6). By properly sequencing and controlling the pulse
width and amplitude of the DC pulses applied to
electromagnets 26, 28, the rotational speed and torque
15 output from the radial/rotary propulsion system may be
controlled. If a two-way (not one-way) bearing assembly
14 has been used, the direction of rotation may also be
controlled. The use of short duration pulses
facilitates high speed operation. By using a capacitive
20 discharge type power supply, even with narrow pulses,
enough energy may be imparted to the flywheel to
maintain high torque output at these high operating
speeds. Typically, magnets diametrically opposed (i.e.,
180° apart from one another on the flywheel) are pulsed
25 simultaneously. This minimizes lateral thrust forces on

bearing 16 and thereby prevents excessive wear on bearing 16 as well as minimizing friction among bearing 16, flywheel 12 and axle 14.

Referring now to FIGURE 8, there is shown a plan view of a simplified embodiment of the present invention, generally at reference number 60. In this simplified embodiment, flywheel 12 is connected to axle 14 by means of bearing 16. Magnet group 22, however, consists of only two magnets 18, disposed on flywheel 12 diametrically opposed to one another. Likewise, magnet group 24 consists of only two magnets 18, also shown diametrically opposed to one another. While magnet groups 22 and 24 are depicted having an orthogonal relationship to one another, it should be obvious to those skilled in the art that any angular relationship between magnet groups 22 and 24 could be chosen to meet a particular operating requirement or circumstance. Likewise, a combination of the embodiment of FIGURES 1 and 2 with the embodiment of FIGURE 8 could also be created. Such an embodiment (not shown) could have two magnets in magnet group 22 and a large number of magnets in magnet group 24, or vice-versa.

Referring now again to FIGURES 1 and 2, it is important that a spacing between individual magnets 18

and 20 be chosen so that any magnetic interference between adjacent magnets is held below a critical operating threshold. Failure to provide sufficient spacing between magnets 18, 20 may, worst case, prevent operation of the inventive propulsion system. If insufficient spacing is provided, the system may be partially operative but efficiency and/or range of control may suffer.

The radial/rotary propulsion system of the instant invention also features a regeneration system to recapture electrical energy from flywheel inertia during a coast (non driven) mode of operation. Typically the regeneration is implemented using separate components (i.e., magnets, pick-up coils, alternators, etc.) than those used to drive flywheel 12. This will be described in detail hereinbelow. It is possible, however, by using appropriate control circuitry (not shown), to utilize the drive components, particularly electromagnets 26, 28 so that when they are no longer operating in a driven mode, they may be used in a reverse process during a coast (non driven or recovery) mode of operation, to recapture the inertia of flywheel as electrical energy. The recaptured energy may be used to partially recharge battery 38 (FIGURE 6). In one embodiment, permanent magnets 18 and/or 20 interact with

electromagnets 26, 28, respectively, to act as a generator. This requires a special switching arrangement (not shown) in controller/sequencer 40 (FIGURE 6) to accomplish this function. Such switching arrangements are well known to those in the electrical engineering arts and form no part of the instant invention. In alternate embodiments, additional magnets and coils, as are described in detail hereinbelow, may be used to perform the regeneration function.

More typically, separate components are used to implement the regeneration mode. Referring now to FIGURE 3, there is shown a schematic view of an alternate embodiment of the regeneration system. In an this embodiment, an additional set of permanent magnets 34, also arranged in a substantially circular pattern, typically at a radius between the two radii associated with magnets 18 and 20, are also affixed to flywheel 20. Special alternator pick-up coils 36, optimized as electrical generating structures are deployed as nearly as possible to magnets 34. In this embodiment, no special switching arrangement of electromagnets 26, 28 is required and simple regeneration circuitry (not shown), well known to those skilled in the circuit design art, may be used. The regeneration circuit also serves as a brake for flywheel 12 because, as inertial

energy is converted to electrical energy, the rotation of flywheel 12 is slowed and, ultimately, stopped. This is useful when the radial/rotary propulsion system of the invention is used to power a land vehicle by direct wheel power application. Energy which would normally be wasted may be scavenged by the regeneration system, thereby both saving wear on mechanical brakes and allowing a greater operating range for the vehicle between battery charges.

Referring now to FIGURE 4, magnets 18', 20' are shown partially embedded in flywheel 12. This type of mounting arrangement provides a more secure containment of magnets 18', 20' than does simple surface mounting.

Referring now to FIGURE 5, there is shown another embodiment of a magnet placement. Magnets 18'' and 20'' are shown extending completely through flywheel 12. Magnets 18', 20' (FIGURE 4), 18'' and 20'' are shown projecting beyond the surface of flywheel 12. This is not necessary and, indeed, it may be preferable in some environments to keep the surfaces of magnets 18', 20', 18'' and 20'' flush with the surface of flywheel 12.

In operation, the placement of magnets in at least two concentric rings allows for excellent control of

both velocity and torque from the radial/rotary propulsion system.

Referring now to FIGURE 6, there is shown a system schematic block diagram of the instant invention. A rechargeable battery 38 is connected to a controller/sequencer 40. Recharge power for battery 38 is applied to controller/sequencer 40 at recharge input (alternator) connection 42. Throttle 44 and brake 46 control signals are applied to controller/sequencer 40. It will be obvious to those skilled in the art that the throttle and brake signals may be generated by a wide variety of transducers known to those skilled in the art. In addition, it will be obvious to those skilled in the design of land vehicles that inputs other than throttle and brake may be required to make a fully functional vehicle control system. These inputs could readily be added to controller/sequencer 40, if required. Controller/sequencer 40 includes capacitive discharge circuits (not shown) which allow energy from battery 38 to relatively slowly charge one or more capacitors (not shown). When controller/sequencer 40 energized one or more electromagnets 26, 28, a high energy, short duration pulse may be provided to electromagnets 26, 28. Capacitive discharge circuits are also well known to those skilled in the electrical

engineering arts. Controller/sequencer 40 provides a plurality of outputs to electromagnets 26, 28 (FIGURE 2). There may be as many outputs from controller/sequencer 40 as there are electromagnets 26, 28, each electromagnet being individually controlled. In alternate embodiments, groups of electromagnets associated with each of the first magnet group 22 (FIGURE 1) and/or the second magnet group 24 (FIGURE 1) could be combined (i.e., multiple electromagnets in each group could be simultaneously energized) thereby reducing the number of switching components (not shown) within controller/sequencer 40 and simplifying the electromagnet wiring (not shown). Under most circumstances, electromagnets 26, 28 which correspond to magnets 18, 20 which are diametrically opposed, will be fired simultaneously. This practice tends to equalize lateral thrust stresses on bearing 16 (FIGURES 1 and 2) and tends to provide smoother control of the inventive system. It should, however, be obvious to those skilled in the motor control arts that alternate control arrangements could be provided to accommodate a particular operating circumstance or environment

Referring finally to FIGURE 7, there is shown a schematic of a typical electrically powered vehicle, reference number 50. The vehicle 50 chosen for purposes

of disclosure is equipped with four wheels. It should be obvious that the radial/rotary propulsion system of the invention could readily be applied to many different vehicle configurations from a unicycle to a multi-
5 wheeled transport vehicle. Front wheels 52, each equipped with a radial/rotary propulsion system, are coupled to a steering wheel 54 by means of steering box 56. Vehicle 50 is also equipped with a pair of rear wheels 58 which may also be equipped with the
10 radial/rotary propulsion system of the instant invention. In still other embodiments, four wheel drive could be provided, front and rear wheel being independently equipped with the radial/rotary propulsion system of the present invention. In alternate
15 embodiments, only rear wheels 58 may be equipped with the radial/rotary propulsion systems. In still other embodiments, the vehicle could remain essentially conventional and only the engine be eliminated and replaced with a radial, rotary propulsion system mounted
20 to the transmission. Controller/sequencer 40 is shown located in the front of vehicle 50 but could readily be located any convenient place within the body of vehicle 50. Battery 38 (FIGURE 6) has not been shown in vehicle 50. In common practice, battery 38 is made from
25 multiple cells of the lead/acid type which many be

distributed through the vehicle as required for good weight distribution and acceptable body styling,

5 It should be obvious that in alternate embodiments, electromagnets could be deployed on or in the flywheel in concentric, circular patterns and permanent magnets could be located adjacent the flywheel. Power to the electromagnets could be provided through slip rings or in other manners well known in the art.

10 It is to be understood that the present invention is not limited to the embodiments described above, but encompasses any and all embodiments within the scope of the following claims.